

**OPTICAL DISC, METHOD AND APPARATUS FOR MANAGING  
A DEFECTIVE AREA ON AN OPTICAL DISC OF WRITE ONCE  
TYPE**

**[0001]** This application claims the benefit of the Korean Patent Application Nos. 2002-058515 filed on September 26, 2002 and 2003-002330 filed on January 14, 2003, the entirety of each of which are hereby incorporated by reference.

**BACKGROUND OF THE INVENTION**

**Field of the Invention**

**[0002]** The present invention relates to a method for managing a defective area on a high density optical disc, and more particularly to a write once optical disc, an apparatus and a method for managing and efficiently recording defect management information for a defective area on a high density optical disc such as a Blu-ray Disc Write Once (BD-WO) type.

**Background of the Related Art**

**[0003]** Optical discs on which a large capacity of data can be written as optical recording media have been widely used in the background art. Among these new high density physical formats being developed is a new HD-DVD (High-Density Digital Versatile Disc) on which high quality video and audio data can be written and stored in large quantities, e.g., a BD (Blu-ray Disc).

**[0004]** The Blu-ray disc is the next-generation optical recording solution that can surpass the data recording capability of existing DVDs. The world standard specifications for the Blu-ray disc HD-DVD have recently been established. The Blu-ray disc uses a celadon (blue-ultraviolet) laser having a wavelength of 405 nm that is much denser than the red laser having a wavelength of 650 nm that is typically used for existing DVD technology. Accordingly, a larger amount of data than the existing DVD can be stored on the Blu-ray disc that has a thickness of 1.2 mm, a diameter of 12 cm, and an optical transmission layer having a thickness of 0.1 mm.

#### **SUMMARY OF THE INVENTION**

**[0005]** Accordingly, the present invention is directed to a method of managing a defective area on an optical disc write once that substantially obviates one or more problems due to limitations and disadvantages of the related art.

**[0006]** An object of the present invention is to provide a method of managing a defective area on an optical disc of write once type that can efficiently replace data recorded in a defective area of a disc as replacement data.

**[0007]** An object of the present invention is to provide a method of managing a defective area on an optical disc of write once type that can efficiently record replacement data in a spare area to prevent data recording errors.

**[0008]** One or more of these and other objects of the present invention are accomplished by a method for managing an optical recording

medium having at least one defective area in a user data area, the method comprising recording data recorded in the defective area in a spare area of the optical recording medium as replacement data and providing a first temporary defect list having a defect entry for the at least one defective area; and recording a cumulative temporary defect list for an additional defective area in the user data area, wherein the cumulative temporary defect list includes the first temporary defect list previously recorded and at least one additional defective entry for any additional defective area.

**[0009]** One or more of these and other objects of the present invention are further accomplished by a recording medium comprising at least one spare area within a data area; a temporary defect management area for managing replacement data of at least one defective area within a user data area of the data area; and a cumulative temporary defect list stored within the temporary defect management area, wherein the cumulative temporary defect list includes management information for the replacement data of the at least one defective area cumulatively recorded and management information for replacement data for at least one additional defective area of the user data area.

**[0010]** One or more of these and other objects of the present invention are further accomplished by an apparatus for managing an optical recording medium having at least one temporary defect management area, and a spare area in a data area, the apparatus comprising a device for recording data recorded in at least one defective area of the spare area of the optical recording medium as replacement data and providing a first temporary defect list having a defect entry for the at least one defective area; and a device for recording a cumulative temporary

defect list for an additional defective area in a user data area, wherein the cumulative temporary defect list includes the first temporary defect list previously recorded and at least one additional defective entry for any additional defective area.

**[0011]** It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0012]** The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

**[0013]** FIG. 1 schematically illustrates the construction of a general optical disc recording/reproducing apparatus according to an embodiment of the present invention;

**[0014]** FIG. 2 illustrates a method of managing a defective area on a general BD-RE;

**[0015]** FIG. 3 is a block diagram of an optical disc recording and reproducing device according to another embodiment of the present invention;

**[0016]** FIGS. 4A and 4B illustrate a structure of a single layer BD-WO and a dual layer BD-WO optical disc, respectively, according to an embodiment of the present invention;

**[0017]** FIG. 5 illustrates a method of managing a defective area on an optical disc of write once type according to a first embodiment of the present invention;

**[0018]** FIG. 6 illustrates management information created and recorded by the method of managing a defective area on an optical disc of write once type according to the first embodiment of the present invention;

**[0019]** FIG. 7 illustrates a method of recording a temporary defect list on an optical disc of write once type according to the present invention;

**[0020]** FIG. 8 illustrates a method of managing a defective area on an optical disc of write once type according to a second embodiment of the present invention;

**[0021]** FIG. 9 illustrates management information created and recorded by the method of managing a defective area on an optical disc of write once type according to the second embodiment of the present invention; and

**[0022]** FIGS. 10 and 11 illustrate examples of the method of managing a defective area on an optical disc of write once type according to the second embodiment of the present invention.

#### **DETAILED DESCRIPTION OF THE INVENTION**

**[0023]** Reference will now be made in detail to the method and apparatus for managing a defective area on an optical disc write once according to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

**[0024]** As various kinds of standards relating to the Blu-ray disc have been prepared, standards for BD-RE (Blu-ray Disc Rewritable) and BD-WO (Blu-ray Disc Write once) are being developed for various applications. As seen in FIG. 1, an apparatus for recording/reproducing a signal on an optical disc, such as a BD-RE, may include an optical pickup 11 for recording/reproducing the signal on the optical disc 10, a VDR (Video Disc Recorder) system 12 for processing the signal readout from the optical pickup 11 or modulating an externally inputted data stream into a signal suitable for being recorded to process the modulated signal, and an encoder 13 for encoding an externally inputted analog signal and outputting the encoded signal to the VDR system 12.

**[0025]** As seen in FIG. 2, the BD-RE is divided into, and assigned a lead-in area (LIA), a data area, and a lead-out area (LOA). The data area is provided with a user data area, and an inner spare area (ISA) and an outer spare area (OSA) assigned to a leading end and a rear end of the user data area, respectively.

**[0026]** The VDR system 12 of the optical disc recording/reproducing apparatus as constructed above encodes and modulates the externally inputted data into the signal suitable for being recorded, and then writes the modulated signal in a cluster, e.g., a unit that corresponds to the unit of an ECC (Error Correction Coding) block having a specified recording size. As shown in FIG. 2, if a defective area is detected in the data area during recording of the data, a series of replacement recording operations for replacement recording of the data recorded in the defective area are performed in a cluster of a spare area, e.g., in the ISA.

**[0027]** Accordingly, even if the defective area exists in the data area of the BD-RE, the VDR system 12 of the optical disc recording/reproducing apparatus records the data recorded in the defective area in the single cluster in the spare area. During the reproduction of data, the VDR system 12 reads out and reproduces the data replaced/recorded in the spare area, so that any data recording errors can be prevented in advance.

**[0028]** As the name of the BD-WO may suggest, data can be written only once on the BD-WO and is not re-writable on the BD-WO. However, the BD-WO can be read repeatedly. As a result, the BD-WO is useful where the rewritability of data on a recording medium is not desired or essential. However, an efficient defective area management scheme for the BD-WO, the second standardization of Blu-ray disc discussed hereinabove, has not yet been prepared and is therefore required.

**[0029]** FIG. 3 is a block diagram of an optical disc recording and/or reproducing device 20 according to a preferred embodiment of the present invention. The optical disc recording and/or reproducing device 20 (hereinafter optical disc recording/reproducing device) includes an optical pickup 22 for writing and reading data to and from an optical recording medium 21, a servo unit 23 for controlling the pickup 22 to maintain a distance between an objective lens of the pickup 22 and the recording medium 21 and for tracking relevant tracks on the recording medium 21, a data processor 24 for processing and supplying input data to the pickup 22 for writing, and for processing data read from the recording medium 21, an interface 25 for exchanging data and/or commands with any external host 30, a memory or storage 27 for storing information and data therein including defect management data associated with the recording medium

21, and a microprocessor or controller 26 for controlling the operations and elements of the recording/reproducing device 20.

**[0030]** Data to be written or read to or from the recording medium 21 may also be stored in the memory 27. All the components of the recording/reproducing device 20 are operatively coupled. In the exemplary embodiment shown, the recording medium 21 is a recording medium of write-once type, e.g., such as a BD-WO.

**[0031]** FIGS. 4A and 4B illustrate a structure of a single layer BD-WO and a dual layer BD-WO optical disc, respectively, according to an embodiment of the present invention. As shown in FIGS. 4A and 4B, the BD-WO can have one or two recording layers. In FIG. 4A, a BD-WO having only a single recording layer (Layer 0) includes a single recording layer composed of a lead-in area (LIA), a data area, and a lead-out area (LOA), and is referred to herein as a single layer disc.

**[0032]** In FIG. 4B, a dual layer BD-WO includes two recording layers (Layers 0 and 1) and is referred to hereinafter as a dual layer disc. The first recording layer (Layer 0) includes a LIA, a data area, and an outer zone. The second recording layer (Layer 1) includes a LOA, a data area and an outer zone. Generally, a data writing occurs in the direction shown with the dotted arrow in the dual layer disc. The single layer disc can have a capacity of 23.3, 25.0 or 27.0 Gbytes, whereas the dual layer disc can have a capacity of 46.6, 50.0, or 54.0 Gbytes.

**[0033]** It should be noted that all the different embodiments of the present invention, e.g., various methods discussed hereinafter, are applicable to any type of an optical disc, such as a single layer BD-WO, a dual layer BD-WO or a BD-RE. Further, although the use of the optical

disc recording/reproducing device 20 of FIG. 3 is discussed below in conjunction with the methods of the invention, the invention is not limited to such and encompasses other recording/reproducing devices as long as they are configured to implement the present methods. For instance, the device shown in either FIG. 1 or FIG. 3, e.g., the VDR system 12 or the optical disc recording/reproducing device 20 may be used to implement the present methods as needed.

**[0034]** FIG. 5 illustrates a method of managing a defective area on an optical disc of write once type according to a first embodiment of the present invention. For example, the BD-WO (Blu-ray Disc Write Once) includes an LIA (Lead-In Area), a data area, and an LOA (Lead-Out Area). The data area may be divided into a user data area where a PSN (Physical Sector Number) and an LSN (Logical Sector Number) are simultaneously given and a non-user data area where only the PSN is given.

**[0035]** The non-user data area, as shown in FIG. 5, is divided into an ISA (Inner Spare Area) and an OSA (Outer Spare Area) for replacement-recording data of a defective area. The LIA is divided into a TDMA (Temporary Defect Management Area) for temporarily recording management information of the defective area and the replacement-recorded data, and a DMA (Defect Management Area) for generally permanently recording defect management information. However, FIG. 5 shows only an example of the positions of the TDMA and the DMA, and their positions may be changed. For example, the DMA may also be arranged in the LOA, and the TDMA may additionally be arranged in the data area if needed.

**[0036]** In the case of a general rewritable optical disc, data can be repeatedly written in and erased from a DMA, even if the DMA has a limited size, and a DMA of a large size is therefore not required. However, in the case of an optical disc of write once type, once an area has been used for recording data, this area cannot be used for data recording again. Accordingly, a defect management area of a larger size is required in optical discs of this type. Also, if no further recording is made on the optical disc of write once type, e.g., in the case where the optical disc of write once type is finalized, the final TDMA information needs to be transferred to the DMA. This defect management area is referred to as the TDMA (Temporary DMA), e.g., as distinguished from the DMA. Accordingly, the TDMA can be regarded as a distinguishing feature of the structure of the optical disc of write once type according to the present invention.

**[0037]** In the TDMA, a TDFL (Temporary Defect List) where information on the defective areas and the position information of the replacement-recorded areas are recorded and managed in the form of a list and general management information of the disc are recorded. According to the present invention, a TDDS (Temporary Disc Definition Structure) for storing the position information of the TDFL is recorded in the TDMA. However, the structure and relationship between TDFL and TDDS will be explained in greater detail hereinafter with reference to FIGs. 6 and 7.

**[0038]** Meanwhile, the optical disc recording/reproducing device 20 as described above with reference to FIG. 3 sequentially records data in a predetermined recording region of the user data area during the data recording operation. In order to detect the defective area while the data recording operation is performed, a recording size corresponding to one or

more physical tracks or recording unit(s) (in case of the BD-WO, a single cluster) may be set as a DVU (Defect Verifying Unit) in the predetermined recording region. In addition, this DVU can be set to have a range of sizes according to the design of the system.

**[0039]** Also, the optical disc recording/reproducing device 20 repeatedly performs a series of operations for detecting the defective area, which includes confirming whether the data is normally recorded by recording data in the DVU and then reproducing the data recorded in the DVU.

**[0040]** For example, as shown in FIG. 5, the optical disc recording/reproducing device 20 detects the defective area by sequentially recording data in first to fifth clusters *Cluster #1 - #5* as a first DVU (*DVU #1*, step S10), and then sequentially reproducing the data recorded in the first DVU. If the defective area is detected in the second cluster (step S11), the optical disc recording/reproducing device 20 performs the recording operation for replacement-recording the data of the second cluster, e.g., the data of the second cluster temporarily stored in an internal buffer (or the memory 27) of the optical disc recording/reproducing device 20, in the spare area (step S12). Although the process of replacement-recording the data in the OSA is shown in FIG. 5, it will be appreciated that the replacement-recording of data in the ISA is also possible.

**[0041]** The data of the second cluster may be replacement-recorded from the rear end of the OSA or from the fore or lead end thereof. The optical disc recording/reproducing device 20, after the aforementioned replacement recording operation, reproduces the data recorded in the third cluster of the first DVU again, and if the defective area is detected in the

fourth cluster (step S13) at this time, the optical disc recording/reproducing device 20 performs the recording operation for replacement-recording the data of the fourth cluster, e.g., the data of the fourth cluster temporarily stored in the internal buffer or memory of the optical disc recording/reproducing device 20, in the spare area (step S14).

**[0042]** Accordingly, in the first DVU, normally recorded first, third and fifth clusters and two defective areas are recorded, and in the outer spare area, the second cluster and the fourth cluster are replacement-recorded.

**[0043]** If the data recording operation *Recording 1* having a temporary sequence is terminated while the defective area detection and replacement recording operation as described above are repeatedly performed in the unit of a DVU, e.g., DVU #1, DVU #2,..., DVU #n, the optical disc recording/reproducing device 20 records defect management information for managing the defective area and the replacement-recorded data as TDFL (Temporary Defect List) information. Accordingly, the method of recording the TDDS and the TDFL will be explained in greater detail hereinafter.

**[0044]** FIG. 6 illustrates the structures of TDDS and TDFL and the relationship between the TDDS and the TDFL. The TDFL includes a plurality of entries. Each entry within the TDFL includes position information of the defective area (*First PSN of Defective*) and position information of the replacement-recorded area (*First PSN of Replacement*), e.g., this arrangement of entries has been used in the same manner as the existing rewritable optical disc. The TDDS is an area that includes information for managing the disc, and, especially with respect to the

present invention, the TDDS has information on the position of the latest or most recent TDFL (*First PSN of latest TDFL*).

**[0045]** Accordingly, whenever a defective area is detected that requires management, the corresponding entry is recorded in the TDFL. After the recording in the TDFL is completed, information indicative of the position of the corresponding TDFL is recorded in the TDDS. Accordingly, the system can easily access the position of the latest updated TDFL by reproducing the TDDS, and efficient defect management becomes possible by confirming the entries of the corresponding TDFL.

**[0046]** The TDDS and the TDFL are recorded in the TDMA as shown in FIG. 6. If a user requests a disc finalization for terminating the data recording on the optical disc, a series of operations for copying and recording new TDDS and TDFL information stored in the TDMA into a separately arranged DMA are performed during the disc finalization. Accordingly, by confirming the DMA area during a reuse of the disc, it can be easily recognized that the corresponding disc is finalized and that the contents of the final TDDS and TDFL can be confirmed as well. In the case of the recording of the TDDS and the TDFL in the DMA, these structures are referred to as DDS (Disc Definition Structure) and DFL (Defect List), respectively, to indicate finalized information.

**[0047]** FIG. 7 illustrates a method of recording a TDFL on an optical disc of write once type according to the first embodiment of the present invention. The main characteristic of this method is a cumulative use of the TDFL. Since the preservation of defect entries is critical to successful defect management, the cumulative recording method is used so that the entries can be protected cumulatively with previous TDFL information

throughout the recording of the TDFL information. Further, by simply confirming the final TDFL information, all defect information produced up to that point can be conveniently confirmed at a single reference location.

**[0048]** Specifically, if two defect entries existed in the n-th recorded TDFL, the two n-th defect entries (*Defect\_Entry #1* and *Defect\_Entry #2*) previously recorded are recorded during the recording of the TDFL #n+1, and then one entry *Defect\_Entry #3* newly produced is added to the TDFL #n+1. As a result, in the TDFL #n+1, three defect entries exist.

**[0049]** Although FIG. 7 illustrates an example where three entries are sequentially arranged, the present invention is not limited to this example. For instance, the entries may be recorded according to a specified sorting type such as *Defect\_Entry # 3, #1, #2* and so on. In the same manner, the TDFL #n+2 includes the TDFL # n+1 information and a presently added new defect entry, e.g., *Defect\_Entry #4*.

**[0050]** FIGs. 8-11 illustrate a method of managing a defective area on an optical disc of write once type according to a second embodiment of the present invention. Irrespective of the cumulative recording of TDFL according to the first embodiment, the second embodiment provides a repeated recording of TDFL presently updated in different areas of the disc. For example, if the TDFL (n+1)-th is to be updated, the TDFL (n+1)-th recorded with the contents of the TDFL n-th, and/or the entry added to the TDFL (n+1)-th, are recorded in different areas of the disc at least twice. Therefore, the second embodiment of the present invention, in the same manner as the first embodiment, provides a copy of the TDFL information in the disc as a backup in order to prevent the loss of important TDFL information.

**[0051]** More specifically, FIG. 8 illustrates a method of managing a defective area on an optical disc of write once type according to the second embodiment of the present invention. For example, the BD-WO (Blu-ray Disc Write Once) includes an LIA (Lead-In Area), a data area, and an LOA (Lead-Out Area). The data area may be divided into a user data area where a PSN (Physical Sector Number) and an LSN (Logical Sector Number) are simultaneously given and a non-user data area where only the PSN is given. The non-user data area, as shown in FIG. 8, is divided into an OSA (Outer Spare Area) for replacement-recording data of a defective area and a TDFL (Temporary Defect List) area for recording management information of the defective area and the replacement-recorded data.

**[0052]** The optical disc recording/reproducing device 20 as described above with reference to FIG. 3 sequentially records data in a predetermined recording region of the user data area of the BD-WO in FIG. 8 during the data recording operation. In order to detect the defective area while the data recording operation is performed, a recording size corresponding to one or more physical tracks or recording units (in case of the BD-WO, a single cluster) may be set as a DVU (Defect Verifying Unit) in the predetermined recording region. In addition, the DVU can be set to have a range of sizes according to the design of the system.

**[0053]** The optical disc recording/reproducing device 20 repeatedly performs a series of operations for detecting defective area(s), which includes confirming whether the data is normally recorded by recording data in the DVU, and then reproducing the data recorded in the DVU.

**[0054]** For example, as shown in FIG. 8, the optical disc recording/reproducing device 20 records the temporary defect list

information in the TDMA dividedly arranged in the lead-in area as main TDFL *Main\_TDFL* information, and repeatedly records the TDFL information in the TDFL area arranged in the head of the recording region of the data area as sub TDFL *Sub\_TDFL* information as well.

**[0055]** The repeatedly recorded main and sub TDFL information, as shown in FIG. 9, includes a plurality of defect entries *Defect\_Entry #1- #m*. A first physical sector number of the defective area *First PSN of Defective* and a first physical sector number where the corresponding data is replacement-recorded *First PSN of Replacement* may be recorded in relationship to each other in each of the defect entries.

**[0056]** Therefore, the optical disc recording/reproducing device 20 records the main TDFL (*Main\_TDFL*) information and the TDDS information for rapidly accessing the repeatedly recorded main and sub TDFL information in the TDMA separately arranged in the lead-in area. Here, for example, the TDDS information, as shown in FIG. 9, includes physical sector numbers (*First PSN of latest M\_TDFL*) and (*First PSN of latest S\_TDFL*) for indicating a new, latest TDFL (*TDFL #2*) included in each of the main TDFL (*Main\_TDFL*) information and the sub TDFL (*Sub\_TDFL*) information.

**[0057]** Also, if a user requests a disc finalization for terminating the data recording on the optical disc, a series of operations for copying and recording the TDDS and main TDFL information stored in the TDMA into one or more DMAs separately arranged in the lead-in area are performed, e.g., as shown in FIG. 9.

**[0058]** Thus, if a defect is included in the main TDFL information recorded in the BD-WO, the optical disc recording/reproducing device 20

can alternatively or in conjunction search the repeatedly recorded sub TDFL, thereby improving the security and integrity of the TDFL information.

**[0059]** Therefore, the TDFL information may be recorded two or more times as described hereinabove. As shown in FIG. 10, the TDFL information can be recorded in the lead-in area, i.e., the recording region preceding the data area, and in the recording region at the edge of the data area (next to the OSA in FIG. 10) two or more times. Also, as shown in FIG. 11, the TDFL information may be recorded in the leading portion or the rear portion of the data area two or more times, or sequentially recorded therein.

**[0060]** For reference, the TDFL information repeatedly recorded at least twice according to the present invention may be dividedly recorded in another recording region in addition to the specified recording region described with reference to FIGs. 8 to 11, for example, in a partial recording region of the outer spare area or in the lead-out area. Also, the TDDS information may be repeatedly recorded at least twice to secure the stability of the information.

**[0061]** It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.